Project ORION: Orbital Debris Removal Using Ground-Based Laser and Sensor Systems

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Presently, it is estimated there are 150,000 orbital debris particles ranging in size from 1 to 10 cm. This size range is too small to be reliably tracked, too numerous to easily allow avoidance mitigation, and too large to easily allow shielding mitigation. This debris at altitudes above 200 km pose a significant threat to many low-Earth-orbit space-based platforms such as Space Station. A study was conducted to determine the feasibility of using ground-based laser and sensor (e.g., radar) systems to remove this debris.

This study was initiated by Ivan Bekey at NASA Headquarters, co-sponsored by the USAF Space Command, and included a team of laser experts managed by Dr. Jonathan W. Campbell at MSFC. The study team included the USAF Phillips Laboratory, MIT Lincoln Laboratories, MSFC, Northeast Science and Technology, Photonic Associates, and the Sirius Group.

The objective of this work was to determine the feasibility of using ground-based lasers and sensors to accomplish orbital debris removal.

All aspects of the problem were considered including the nature and characteristics of the orbital debris population, the interaction of a number of different lasers and radars with the spectrum of debris categories, laser atmospheric transmission effects, available laser and sensor technology, and associated costs. Current and near-future laser technology are not sufficient to vaporize a debris particle in low-Earth orbit; however, a thin layer of the debris surface can be ablated. This ablation then provides a small change in the orbital velocity of the particle. If the point of interaction is chosen carefully by the laser operator, this velocity will lower perigee. A pulsed laser produces a large number of these interactions over a short period of time ultimately bringing perigee below the critical altitude of 200 km. Below these altitudes, atmospheric drag will dictate particle reentry in a few hours to a few days at most.

The study was completed successfully showing that it was feasible with substantive margin to remove orbital debris by using ground-based systems.

The launch costs associated with shielding just one critical asset, the space station, against 1- to 2-cm debris is estimated to be on the order of $100 million. For a similar cost, all debris could be removed below 800 km and all space-based assets at and below these altitudes could be protected.

A demonstration experiment could be accomplished for about $20 million using existing off-the-shelf laser and sensor hardware. This experiment would demonstrate the feasibility of detecting, tracking, pointing, and changing the orbit of selected debris targets using a ground-based laser/sensor system.

Also, the study revealed that for $60 million using near-term technologies all orbital debris below 800 km could be removed, thus protecting Space Station and all other assets at these altitudes. This operational system would consist of a Nd:glass laser operating at 1.06 μm with a pulse width of 5 ns operating at a rate of 1 to 5 Hz. It would have 3.5 m diameter optics, operate with a single sodium guide star, and produce 5 kJ pulses.

For an additional $80 million, more exotic technologies might be employed to remove all orbital debris below 1,500 km.

NASA TM Project Orion: Orbital Debris Removal Using Ground-Based Sensors And Lasers.

Sponsor: NASA Headquarters; Office of Aeronautics; USAF Space Command

University/Industry Involvement: USAF Phillips Laboratory; MIT Lincoln Laboratories; Northeast Science and Technology; Photonic Associates; and the Sirius Group.

Biographical Sketch: Dr. Jonathan W. Campbell is an astrophysicist/space scientist working in the advanced concepts area of Marshall Space Flight Center’s Program Development Directorate. Dr. Campbell holds five degrees, including a Ph.D in both engineering and science from both the University of Alabama and Auburn University. He is a colonel in the U.S. Air Force Reserve and a certified instrument flight instructor.